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TITLE Analysis of Qualification Test Base Heat Shield Panels

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ABSTRACT

Qualification test base heat shield panels 60B20210-1 and 60B71590 were examined to determine the M-31 and honeycomb panel mechanical properties. This investigation also contains results of a thermal test on an uninsulated honeycomb panel. Results indicated that the mechanical properties of the M-31 were what would normally be expected after being subjected to the thermal environment of the tests. It was also shown that failure of the brazed honeycomb panel would occur if M-31 were lost after 85 seconds of the S-1C flight.

KEY WORDS

Base Heat Shield
Honeycomb Panel Properties
M-31 Properties
Thermal Test

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1.0 OBJECT

The object of this investigation was to examine two base heat shield panels subjected to qualification tests in order to determine a cause for failure of one of the panels; and to determine what effect loss of M-31 during the latter part of the flight of the S-1C would have on the brazed honeycomb heat shield panels.

2.0 BACKGROUND

The S-1C base heat shield was undergoing qualification tests in Seattle when the thermal-acoustic test of a 60B20210-1 panel was terminated because of equipment failure. Visual examination of the panel after the partial test revealed that M-31 had been lost from a section of the panel. A 60B71590-9 heat shield panel was then subjected to a full duration thermal-acoustic test without failure. The Interstage and Heat Shield Group requested that the two panels be examined in order to determine a cause for the loss of the M-31 from the panel and to also determine what effect the loss of M-31 would have upon the brazed honeycomb of the heat shield during flight of the S-1C.

3.0 CONCLUSIONS

3.1 The properties of the M-31 from both panels were what is normally expected after being subjected to the thermal environment.of the tests with nothing being noted which would conclusively contribute to a failure.

3.2 The open honeycomb core height of the 60B20210-1 panel was below the minimum drawing requirement indicating inadequate process quality control.

3.3 The thermal test simulating loss of M-31 after 85 seconds of flight revealed that failure of the brazed honeycomb would occur very rapidly once M-31 was lost.

3.4 The brazed honeycomb was apparently not severely deteriorated during the qualification tests since all edgewise compressive strength specimens failed by skin buckling and not by skin-core braze separation.

4.0 RECOMMENDATIONS

It is recommended that closer in-process control be maintained to insure compliance with the drawing requirements.

5.0 PROCEDURES AND RESULTS

5.1 Saturn S-1C base heat shield panels were undergoing qualification testing in Seattle when the thermal-acoustic test of the 60B20210-1 serial number 46 panel was terminated after 85 seconds due to failure of the radiant heat test equipment. Visual examination of the panel after this aborted test revealed that M-31 had been

lost from the center of the panel. A 60B71590-9 panel was then subjected to a full duration thermal-acoustic test without failure. During discussions following these tests, theories advanced as to why one panel failed and one passed ranged from thermal shock of the M-31 during the aborted test to anomolies in the properties of the M-31 or the brazed honeycomb panels. The Interstage and Heat Shield Group through coordination sheet I&HSG-M-40 requested that the two panels be examined in order to determine a cause for the loss of the M-31 from the 60B20210-1 panel.

5.2 The conclusions which can be made from the results of this investigation are as follows:

1. The physical/mechanical properties of the M-31 are as expected after the M-31 being subjected to an elevated test temperature (and from the fact that the M-31 was removed from the panel along the plane across the top of the open honeycomb core.) The variation in the moduli of rupture and elasticity are attributed to thermal shock cracking which occurs during the rapid cooling of the M-31 after being subjected to the elevated test temperatures.

2. The braze quality of the honeycomb was acceptable due to the high edgewise compressive strength and the fact that the panels failed by in-buckling of the face skins and not by skin-core braze separation.

3. The open core height of this 60B20210-1 panel was less than the drawing requirements indicating poor in-process quality inspection.

4. The results indicate almost immediate panel failure should M-31 be lost from the heat shield thereby subjecting an uninsulated panel to the base region thermal environment.

5.3 The M-31 was removed from both the 60B20210-1 and 60B71590-9 panels by cutting the M-31 along a plane parallel to the surface of the M-31 and across the top of the open core. It was realized that testing this portion of the M-31 only would not reveal the true overall properties of the M-31; but, since this was a comparison between two panels, this procedure was considered acceptable for the purposes of this investigation. The M-31 bulk density and water absorption were determined in accordance with ASTM:C20-46 (Reference 1) except that a sample weight of approximately 50 grams was designated. The moduli of rupture and elasticity for the M-31 were determined in accordance with ASTM C120-52 (Reference 2) except that a sample size of approximately 6" x 1" x $\frac{1}{4}$" was designated and the distance between the supports fixed at 4.00 inches. Also, for the determination of the moduli of rupture and elasticity, the samples were tested with the load being applied to the hard crust side of the M-31. The results of the M-31 tests are shown in Tables I and II. "Standard" refers to those M-31 properties reported in the MSFC document MTP-P&VE-M-62-14 (Reference 3) and are presented for general information

only. The higher values reported in this investigation, as compared with the "standard", are attributed to both in the way the M-31 was removed from the panels and also to elevated temperatures to which both panels were subjected. The variation in the moduli of rupture and elasticity are attributed to the cracks which normally occur in the M-31 after each elevated temperature test.

The remaining M-31 was removed from the open core of the honeycomb panel and the open core height was measured with a depth micrometer. Open core height distribution curves for both the panels are shown in Figures I and II.

The brazed honeycomb panels were then tested for edgewise compressive strength per BAC 5943 (Reference 4). The results for this phase of the investigation are shown in Table III. In all cases, the specimens failed by in-buckling of the face sheets and not by braze failure.

The final phase of this investigation was to subject a brazed honeycomb panel to a thermal environment simulating that which would be expected if M-31 were lost after 85 seconds of flight. Figure III plots the hot and cold face temperatures for this test. Of extreme importance is the fact that the hot face buckled at 93 seconds (8 seconds after the M-31 was supposedly lost from the panel. The test was terminated after 110 seconds because of the danger of the loose hot face sheet falling into the quartz heat lamps. Figure IV is a photograph of the panel after this test.

6.0 REFERENCES

1. Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick. ASTM Designation: C20-46..

2. Flexure Testing of Slate. ASTM Designation: C120-52.

3. Development of a Highly Reflective Unfired Ceramic Thermal Insulation by Vaughn F. Sertzinger. MSFC Document Number MTP-P&VE-M-62-14 dated December 19, 1962.

4. BAC 5943, Silver Brazing Honeycomb Sandwich Structure dated October 6, 1961.

Table I

M-31 Properties for Panel 60B20210-1 _____ Serial Number 46

Specimen No.	Modulus of Rupture (lb/in^2)	Modulus of Elasticity (lb/in^2)
1	945	3.2×10^5
2	450	1.7×10^5
3	960	3.4×10^5
4	675	2.5×10^5
Standard	475	2.5×10^5

Specimen No.	Bulk Density (lb/ft^3)	Water Absorption (%)
1A	59.0	66.4
2A	59.3	65.7
3A	59.3	65.7
4A	59.0	65.5
5A	60.0	64.3
Standard	46.8 - 49.9	75 - 77

Table II

M-31 Properties for Panel 60B71590-9

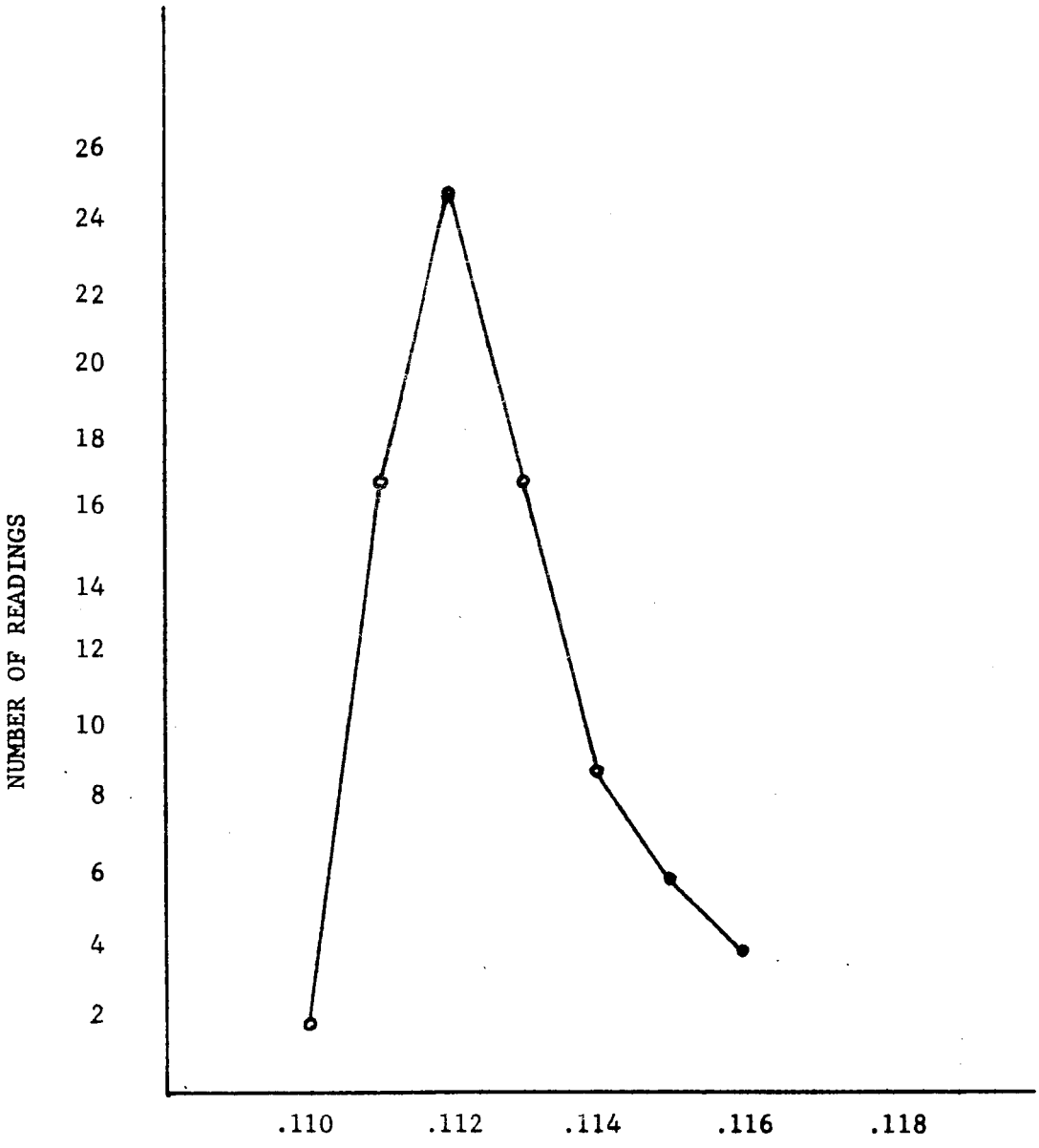
Specimen No.	Modulus of Rupture (lb/in^2)	Modulus of Elasticity (lb/in^2)
1	381	2.0×10^5
2	519	4.0×10^5
3	750	6.4×10^5
4	693	3.3×10^5
5	671	6.5×10^5
6	519	3.5×10^5
Standard	475	2.5×10^5

Specimen No.	Bulk Density (lb/ft^3)	Water Absorption (%)
1A	60.3	62.9
2A	61.4	61.1
3A	60.9	62.5
4A	62.4	59.7
5A	57.8	67.4
Standard	46.8 - 49.9	75 - 77

Table III

Honeycomb Panel Data

Specimen No.	Edgewise Compressive Strength (lb/in^2)	
	Panel Number	
	60B20210-1 S/N 46	60B71590-9
1	133,000	137,400
2	134,700	138,000
3	136,100	135,000
4	133,300	139,000
5	125,800	129,500
6	122,400	
7	133,400	



CORE HEIGHT DISTRIBUTION FOR
60B20210-1 S/N 46 PANEL

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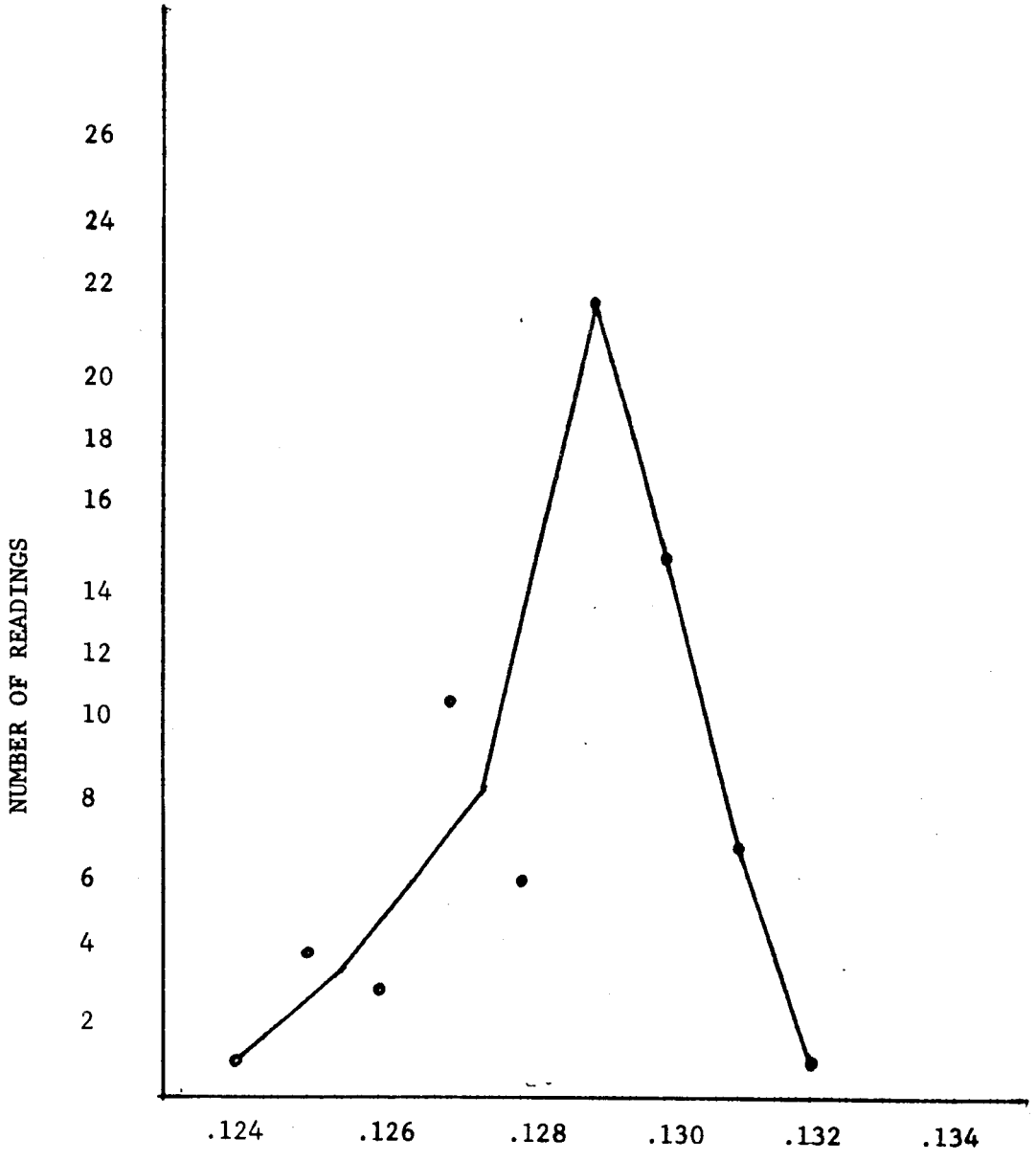

CORE HEIGHT DISTRIBUTION FOR
60B71590-9 PANEL

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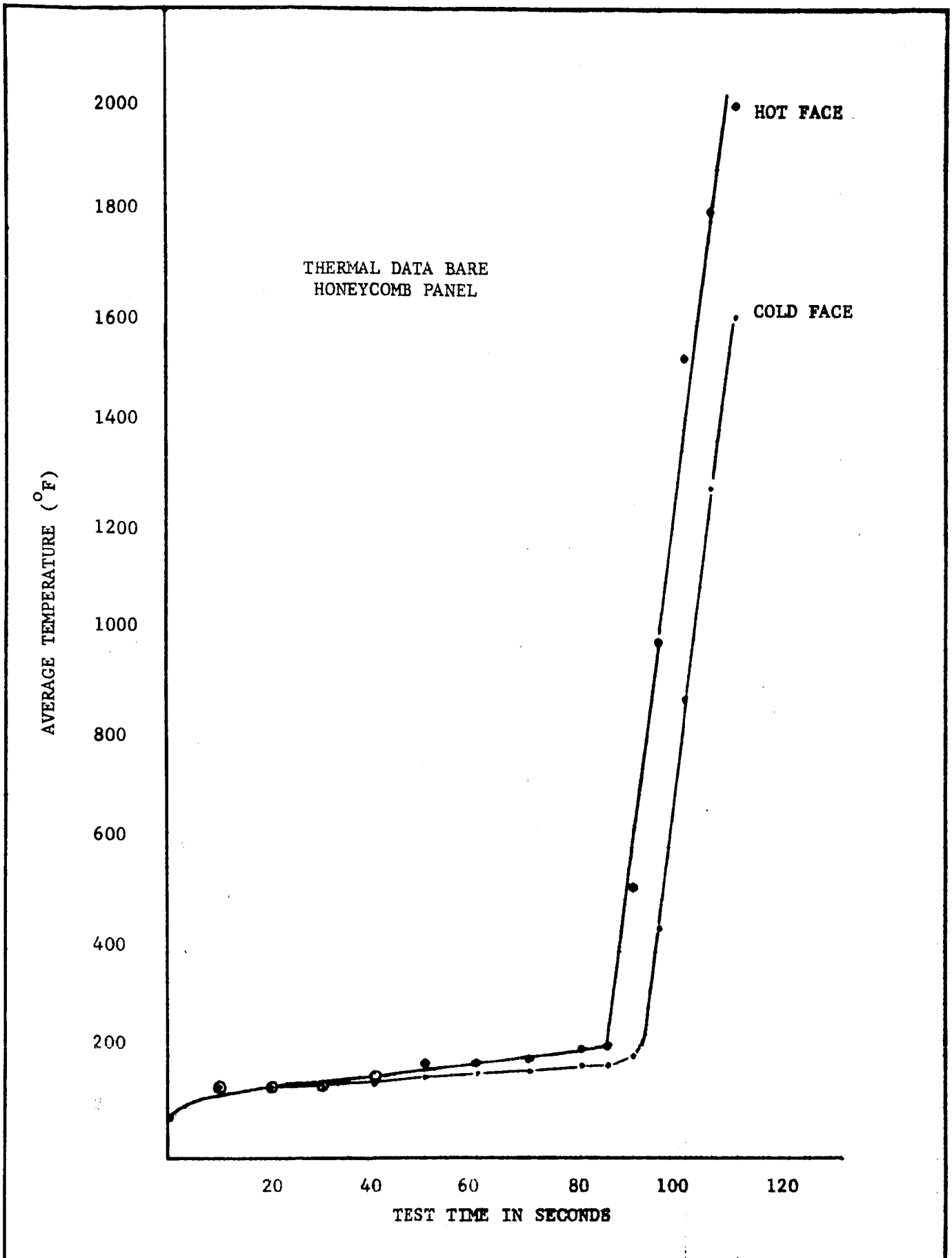

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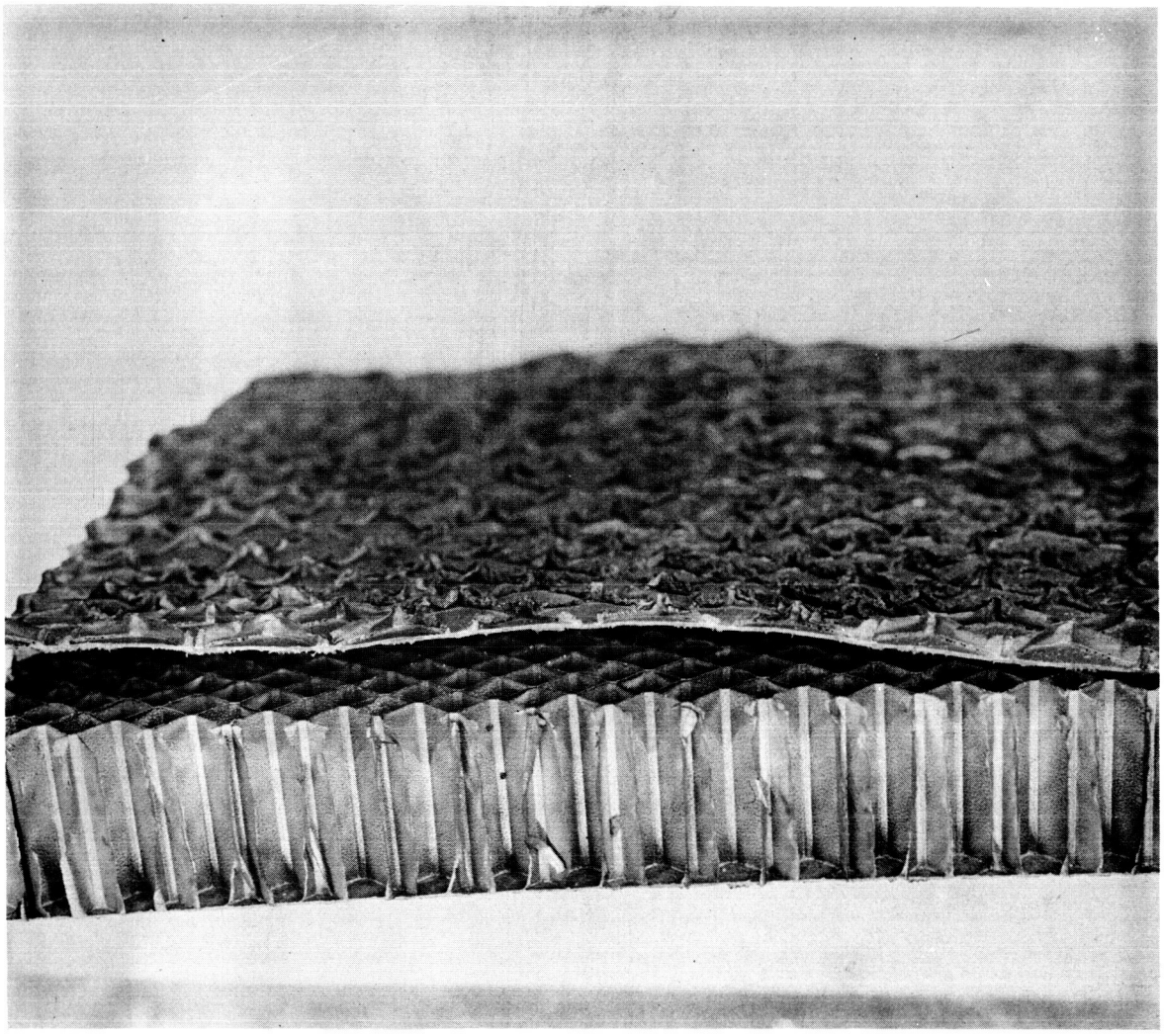

FIGURE IV

HONEYCOMB PANEL AFTER THERMAL TEST